

Hardy Hydroelectric Plant,
Emergency Spillway
6928 East 36th Street
Newaygo Vicinity
Newaygo County
Michigan

HAER No. MI-100-E

HAER
MICH
62-NEWAY
1E-

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

Historic American Engineering Record
United States Department of the Interior
National Park Service
Great Lakes Systems Office
1709 Jackson Street
Omaha, Nebraska 68102-2571

HISTORIC AMERICAN ENGINEERING RECORD

HARDY HYDROELECTRIC PLANT, Emergency Spillway

HAER No. MI-100-E

HAER
MICH
62-NEWAY,
IE-

Location: 6928 East 36th Street
Newaygo Vicinity
Newaygo County
Michigan

UTM: 16:610450:4815900 (north end)
16:610300:4815700 (south end)

Quad: Croton

Dates of
Construction: 1930-1931

Engineers: Edward M. Burd, head of civil and hydraulic engineering for
Consumers Power Company, Jackson, Michigan

Present
Owner: Consumers Energy Company (formerly Consumers Power Company),
Jackson, Michigan

Present Use: Emergency spillway at hydroelectric generating plant

Significance: The Emergency Spillway is part of the dam at the Hardy Hydroelectric Plant, built in the early 1930s as a link in Consumer Power Company's system of electric power generation. In designing and building Hardy, the company found a way to erect a stable, relatively high dam on Michigan's notoriously gravelly foundations, continuing its tradition of developing solutions to the problems presented by Michigan's geography and geology. The design process for the dam also appears to reflect a tendency in American civil engineering to favor regional practices over technology developed elsewhere.

Project
Information: This documentation was prepared by Consumers Power Company (CPCo) in conformance with its Cultural Resources Management Plan for the Muskegon River Hydroelectric Projects (July 1995). The plan stipulated the recordation of the entire Hardy Hydroelectric Plant (according to the standards of the Historic American Engineering Record). The documentation was completed in 1997 by Hess, Roise and Company of Minneapolis under contract with CPCo. Cynthia de Miranda served as Project Historian under the supervision of Principal Investigator Jeffrey A. Hess. Project photography was completed under a subcontract with Hess Roise by Clayton B. Fraser of Loveland, Colorado.

PHYSICAL DESCRIPTION

The Emergency Spillway at the Hardy Hydroelectric Plant (HAER No. MI-100) on Michigan's Muskegon River is one of the plant's two spillways. The service spillway, located in the concrete foundation of the Powerhouse (HAER No. MI-100-B), generally passes flood waters and spring runoff from Hardy Pond. The Emergency Spillway, which occupies the western end of the Embankment (HAER No. MI-100-A), is designed to act as a backup, draining exceptionally heavy flooding from Hardy Pond to prevent overtopping. With a spilling capacity of 40,000 cubic feet per second, the Emergency Spillway can handle flows twice the volume of the operating spillway in the Powerhouse foundation.¹

Three main components make up the Emergency Spillway: a 600'-wide crest; a concrete-lined overflow chute; and an unlined lower channel. The crest, located on the upstream side of the road that crosses the dam, provides 2'-6" of freeboard above the normal maximum headwater elevation of 822'-2". It is equipped with a series of short concrete blocks of various sizes and thickness, designed to topple over in sequence according to the volume of spilled flood waters. This arrangement was employed to avoid a sudden release of water through the spillway, which could cause damage to properties downstream. When 9" of water flows over the weir, the first sections tumble. The next sections follow under a foot of water, while 3'-6" of water are required to topple all the blocks.

Below the crest, the 880'-long concreted channel narrows to a 50'-wide chute with sloping concrete sides. The channel terminates in a concrete ogee weir that empties into an excavated, unlined "bowl" at the base of the paved channel. The upstream half of the bowl is protected on either side by concrete retaining walls.

Below the bowl, the unlined chute directs flood waters back to the Muskegon River well downstream of the plant's tailrace. This unpaved portion extends the Spillway's channel by approximately 1,350'.

¹ Although the dam is actually aligned on a northwesterly-southeasterly axis, full cardinal points are used in descriptions for the sake of clarity. The description is based on engineering drawings, contemporary articles, documents generated by Consumers Power Company, and on a site survey conducted by the authors on 24 July 1995. See Allied Engineers, "General Plan: Hardy Development," Drawing M164-F1272, 11 November 1920, Hydro Operations, Consumers Power Company, Cadillac, Michigan; Edward M. Burd, "Design and Location of Hardy Hydro Plant," *Au Sable News* 17 (August 1931): 29-30; Consumers Power Company, "Application for New License for Major Project-Existing Dam, Hardy Project, FERC Project No. 2452," (no date), Hydro Operations, Consumers Power Company, Cadillac, Michigan; CPCo, "Hardy Hydro Plant-Emergency Spillway Weir," 26 November 1969, historical files, Hydro Operations, Consumers Power Company, Cadillac, Michigan; and "Spillway Operation--Hardy Dam," 8 September 1975, in historical files, Hydro Operations, Consumers Power Company, Cadillac, Michigan.

HISTORY

One of the cardinal rules of building earth embankments instructs builders to prevent overtopping or risk failure of the dam. The primary way to prevent water from flowing over an embankment is to include sufficient spillway capacity in the design. At Consumers Power Company's Hardy Hydroelectric Plant (HAER No. MI-100), the conduit spillway built into the concrete foundation of the Powerhouse (HAER No. MI-100-B) was intended to divert anticipated excess flows created by normal floods and spring runoff. In the event of exceptionally heavy flooding, however, an Emergency Spillway was also included in the plant's design.²

Edward M. Burd, head of civil and hydraulic engineering for Commonwealth Power Corporation—the planning subsidiary for Consumers Power Company—may have found inspiration for his Emergency Spillway design in the writings of consulting engineer Gardner S. Williams of Ann Arbor, Michigan. Williams possessed a varied background and had worked in the hydroelectric field, making observations related to loss of head and designing scroll pits and draft tubes for vertical-shaft water turbines. As a professor of experimental hydraulics at Cornell University, he had run the school's hydraulics lab from 1898 through 1904. Williams then moved to the University of Michigan, where he taught civil, hydraulic, and sanitary engineering from 1904 through 1911. Beginning in 1910, he built a number of earth embankments in northern Wisconsin and Michigan and clearly was familiar with the problems of keeping such dams dry. Burd, who received his bachelor's degree in civil engineering from the University of Michigan in 1911, was undoubtedly aware of Williams's work.³

Responding to a 1923 treatise on earth dam construction published by the American Society of Civil Engineers, Williams included a few lines regarding spillway capacity. "An emergency spillway can be provided by excavating a wide, shallow channel and closing it by a low embankment which in time of extreme flood will be overtopped and carried away, thus giving necessary relief without great damage to the construction."⁴ Burd's Emergency

² Joel D. Justin, "The Design of Earth Dams," *Transactions of the American Society of Civil Engineers* 49 (May 1923): 858-859; Burd, "Design and Location," 29.

³ For more on Williams's career, see Winfield Scott Downs, *Who's Who in Engineering* (New York: Lewis Historical Publishing Co, 1931): 1432-1433.

⁴ Gardner S. Williams, "Discussion on the Design of Earth Dams," *Transactions of the American Society of Civil Engineers* 49 (August 1923): 1321.

Spillway diverged from CPCo's usual spillway configuration—an overflow weir controlled by Tainter gates—to match Gardner's suggestion.⁵

While construction on the Hardy Plant began in September 1929, work on the Emergency Spillway did not get underway until a year later. Crews were finishing the downstream fill for the Embankment (HAER No. MI-100-A) late in 1930, and by December, they began excavation for the bowl of the spillway. Concreting for the upper portion of the chute was done simultaneously, and work on the Emergency Spillway continued through May 1931. As the work neared completion, cracks and bulges began to appear in the concrete, due to pressure from underground springs. Small holes were drilled into the concrete lining to relieve the pressure.⁶

Like the rest of the plant, the Emergency Spillway has seen few significant changes since Hardy opened in 1931. Some time before 1945, ice in the pond damaged the concrete tipping blocks at the lip of the spillway. Riprap was added to the upstream side to help protect the concrete, but the repair apparently increased the water level required to tip the concrete blocks of the weir. The blocks were restored in the 1970s to their original design. In 1988, the crest was modified to allow manual operation of the tipping blocks.⁷

Flooding in September 1986, put the Emergency Spillway into use. Fourteen inches of rain fell in two days, and flood waters collecting in Hardy Pond passed over the spillway for about twenty-four hours. The volume of water, while less than the Emergency Spillway's designed capacity, caused erosion beneath the channel's concrete lining. The torrential rain ended before a break occurred in the spillway, and the dislodged fill was replaced immediately.⁸

⁵ W.W. Tefft, "System and Operating Methods of Consumers Power Company," *Power* 55 (4 April 1922): 526-527.

⁶ Construction account is based on the photographs that documented the erection of the plant. The collection of historic views is maintained at the plant.

⁷ "Hardy Hydro Plant--Emergency Spillway Weir;" and "Spillway Operation--Hardy Dam," in historical files, Hydro Operations, Consumers Power Company, Cadillac, Michigan. Ebasco Services for Consumers Power Company, "Stability Analysis: Hardy Hydroelectric Plant," 28 May 1993, p.3, in Hardy files, Hydro Operations, Consumers Power Company, Cadillac, Michigan.

⁸ For accounts of the flood and its effect on Consumers Power Company dams, see David J. Kolb, "Hardy Dam still holding," *Muskegon Chronicle*, 12 September 1986; Marta K. Dodd, "Mighty Hardy Dam performed well during deluge," *Muskegon Chronicle*, 5 October 1986; and Dave Alexander, "If it happens, the best officials can do is yell 'look out!'" *Muskegon Chronicle*, 19 April 1987.

SOURCES OF INFORMATION

HISTORIC VIEWS

Hardy Hydroelectric Plant construction photographs. Hardy Hydroelectric Plant, Muskegon River, Michigan.

ENGINEERING DRAWINGS

Allied Engineers. "General Plan: Hardy Development," Drawing M164-F1272, 11 November 1920. Hydro Operations, Consumers Power Company, Cadillac, Michigan.

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